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THE INFLUENCE OF VARIETY AND DATE OF PLANTING ON THE RELATIVE COOKING QUALITY OF POTATOES GRADED ACCORDING TO SPECIFIC GRAVITY[1]

R. E. NYLUND[2] AND A. J. POIVAN[3]

Surveys in the United States have indicated that the culinary qualities of potatoes most desired by consumers are a high degree of mealiness, no sloughing, and a snowy white color when the potatoes are boiled, mashed, or baked, (1, 7). To evaluate potatoes properly for these and other culinary qualities objective methods are needed. As indicated by Sweetmen (10) who made an extensive review of the literature, it has long been known that there is an association between mealiness and starch content though this association is not perfect and no chemical explanation of non-correlating cases has been discovered. Since starch is the principal component of the dry matter in potato tubers, the dry matter content of potatoes as determined by specific gravity measurements was proposed by Bewell (2) as an objective method for determining the mealiness of potatoes.

However, as indicated previously, the association between specific gravity and mealiness is not perfect. Haddock and Blood (6) in rating potato varieties and potatoes from various locations state that they found good agreement between specific gravity and mealiness. However, their data show just as large differences in mealiness scores between potatoes of the same specific gravity but grown at different locations as between potatoes of different specific gravities grown at one location. Kirkpatrick, *et. al.* (8) found no significant correlation between specific gravity and mealiness of four varieties of early crop potatoes ranging in specific gravity from 1.06 to 1.08. Whittenberger (11) reported that potatoes of the same specific gravity and variety may vary appreciably in their texture (mealiness) and that high specific gravity tubers varied considerably in sloughing. In addition he found that the degree of sloughing could change after a period of storage at low or high temperature without corresponding change in the specific gravity of the potatoes. Greenwood, *et al.* (4) have recently reported that while the mealiness of six varieties of potatoes grown at one location was closely associated with their specific gravity, the same varieties grown at another location showed little association between mealiness and specific gravity. They concluded that specific gravity alone cannot be safely used as a criterion for mealiness of potatoes.

In spite of the reported variations in the association between specific gravity and mealiness, the specific gravity method has been widely used as a method for estimating the probable mealiness of potatoes (2, 3, 6). Recently, machines have been developed to separate potatoes into specific gravity grades on a commercial scale with the idea of offering to consumers potatoes of two or more specific gravity grades (5, 9).

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Paper No. 2966 Scientific Journal Series, Minnesota Agricultural Experiment Station.

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The present study was undertaken to determine whether or not the specific gravity of uncooked potatoes can be used to estimate any of the characters that are generally considered to be components of "cooking quality" of potatoes.

Materials and Methods

The study reported here consisted of two parts. The first part was a comparison of the relative cooking quality of (a) Irish Cobbler potatoes graded into three specific gravity classes — 1.090, 1.080, and 1.070, (b) Irish Cobbler potatoes harvested from plots planted on three dates and graded into one specific gravity class — 1.080, and (c) Irish Cobbler, Pontiac, and Waseca potatoes graded into one specific gravity class — 1.080. Each of these groups of potatoes was prepared as boiled and as mashed potatoes and then graded by a panel of judges. The second part of the study consisted of supplying 7-8 pound lots of groups (a) and (c) above to homemakers and having these consumers rate each lot of potatoes after cooking.

Throughout the study all lots were identified only by code number so that neither the judges nor the consumers knew the identity of the lots being tested. Each lot given to the consumers had different code numbers so that consumers could not compare ratings.

The Irish Cobblers and Pontiacs used in the study were grown at the Red River Valley Potato Research Farm in 1951. The Wasecas were grown at a farm in the same general area of the Red River Valley.[a] The Irish Cobblers were from plantings made on May 17, May 24, June 4, and June 27 and the Pontiacs and Wasecas were from plantings made between May 17 and May 24. In order to have enough potatoes for the study, the Irish Cobbler tubers of the May 17 and May 24 plantings were bulked.

Each of the above lots of potatoes was separated by the salt water method (6) into the following specific gravity classes:

Specific Gravity Class	Ranges
1.065	1.0625 — 1.0675
1.070	1.0675 — 1.0725
1.075	1.0725 — 1.0775
1.080	1.0775 — 1.0825
1.085	1.0825 — 1.0875
1.090	1.0875 — 1.0925
1.095	1.0925 — 1.0975

For the study, only the Irish Cobbler tubers falling into the classes 1.070, 1.080, and 1.090 and the Pontiacs and Wasecas having a specific gravity of 1.080 were kept. All other tubers were discarded. Thus, in the experimental lots there was no merging of one specific gravity class into the next higher or lower. Specific gravity separations were made during the period November 1951 to January, 1952. During this period all potatoes were kept in a storage cellar at a temperature of 40-50°F.

[a]The writer is indebted to Dr. Herbert Findlen, Horticulturist, U. S. Department of Agriculture, Red River Valley Potato Research Center, and to the Red River Valley Potato Growers Association for providing the potatoes used in this study.

On January 19 all lots for the panel judging were placed in a refrigerator at 36°F. Those for the consumer study were distributed to the consumers on January 25. All lots used in the panel judging were conditioned for one week at approximately 70°F. prior to cooking. Panel judging of boiled potatoes was carried out during the period from January 29 to February 28 and judging of mashed potatoes during the period March 4-27.

Both boiled and mashed potatoes were cooked in copper-bottomed stainless steel kettles and boiled in a minimum amount of water until done as judged by pressing the tubers with a fork[b]. All potatoes were judged without the addition of salt or other ingredients.

The judging panel varied in number from 5 to 8 members at each judging and met four times each week until all lots had been judged both as boiled and mashed potatoes.

Potatoes were judged in groups as follows:

(1) As boiled potatoes:

(a) Group I
(1) Cobbler (5/17 + 5/24 planting) — 1.090
(2) Cobbler (5/17 + 5/24 planting) — 1.080
(3) Cobbler (5/17 + 5/24 planting) — 1.070

(b) Group II
(1) Cobbler (5/17 + 5/24 planting) — 1.080
(2) Cobbler (6/4 planting) — 1.080
(3) Cobbler (6/27 planting) — 1.080

(c) Group III
(1) Cobbler (5/17 + 5/24 planting) — 1.080
(2) Pontiac (5/17 + 5/24 planting) — 1.080
(3) Waseca (5/17 + 5/24 planting) — 1.080

(2) As mashed potatoes:

(a) Group IV
(1) Cobbler (5/17 + 5/24 planting) — 1.090
(2) Cobbler (5/17 + 5/24 planting) — 1.080
(3) Cobbler (5/17 + 5/24 planting) — 1.070
(4) Pontiac (5/17 + 5/24 planting) — 1.080
(5) Waseca (5/17 + 5/24 planting) — 1.080

(b) Group V
(1) Cobbler (5/17 + 5/24 planting) — 1.080
(2) Cobbler (6/4 planting) — 1.080
(3) Cobbler (6/27 planting) — 1.080

Judging of each of the groups was replicated four times. The judging sheet used was patterned closely to that of Kirkpatrick, *et al.* (8) but was modified to allow a numerical score to be assigned for each rating and to allow the judge to give his opinion as to the relative general desirability of each lot judged. A sample judging sheet showing the components of cooking quality rated is shown in table 1. The same sheet was used for both boiled and mashed potatoes except that, of course, the character "sloughing" was not rated for mashed potatoes.

The means of the judges scores for each of the four replicates were used in the analysis of variance to determine ,for each quality component,

[b]The writer is indebted to Miss Shirley Trantanella of the Department of Horticulture who prepared and cooked all lots of potatoes judged.

TABLE 1.—*Judging record for potatoes.*

Name of Judge Date

SAMPLE NUMBER		1	2	3	4	5
Quality Factors	Score Range	Score	Score	Score	Score	Score
Color:						
A—Creamy white	7-9					
B—Slighty yellow or gray	4-6					
C—Yellow or gray	1-3					
(CHECK YELLOW OR GRAY)		Y G	Y G	Y G	Y G	Y G
Sloughing:						
A—Little or no sloughing	7-9					
B—Moderate sloughing or scaling outer layer	4-6					
C—Intense sloughing or disintegration	1-3					
Dryness:						
A—Dry	7-9					
B—Slightly moist	4-6					
C—Watery or soggy	1-3					
Mealiness:						
A—Mealy	7-9					
B—Moderately mealy	4-6					
C—Waxy, cohesive	1-3					
Flavor:						
A—Natural, desirable	7-9					
B—Some off-flavor, slightly undesirable	4-6					
C—Strong off-flavor, undesirable	1-3					
Check for presence of flavors:						
Natural						
Sweet						
Earthy						
Bitter						
Nutty						
Astringent						
Stale						
Watery						
Metallic						
General Desirability:						
A Excellent						
B Good						
C Fair						
E Poor						

the statistical significance of differences between lots within each group.

For the consumer tests, a check sheet was prepared for the consumer to fill out each time she cooked one of the samples of potatoes given her. A sample of the check sheet used is shown as table 2.

TABLE 2.—*Consumer report on potato cooking test.*

Name ..... Address .....

Sample No. ..... Date .....

Instructions: Check (x) the *one* item that applies under each question.

1. How was the sample prepared?
   a. Boiled ( )
   b. Boiled (with jacket) ( )
   c. Mashed ( )
   d. Baked ( )
2. How was the color of the potatoes after cooking?
   a. Attractive (white) ( )
   b. Fair (slightly yellow or gray) ( )
   c. Unattractive (yellow or gray) ( )
3. How dry or moist were the potatoes after cooking?
   a. Dry ( )
   b. Slightly moist ( )
   c. Watery or soggy ( )
4. How was the mealiness of the potatoes after cooking?
   a. Mealy ( )
   b. Somewhat mealy ( )
   c. Waxy (glossy) ( )
5. How did the potatoes hold together on cooking?
   a. Retained normal shape ( )
   b. Broke apart — slightly ( )
   c. Broke apart — very much ( )
6. General desirability.
   a. Excellent ( )
   b. Good ( )
   c. Fair ( )
   d. Poor ( )
7. Comments in regard to sample.

EXPERIMENTAL RESULTS:

Panel Judging

The results of the judging of boiled potatoes are presented in table 3. In comparisons between Irish Cobbler potatoes of three distinct specific gravities, (Group I), the tubers of highest specific gravity were rated significantly higher than those of lower specific gravity for dryness, mealiness, flavor, and general desirability. Also, as has been shown by other workers, potatoes of higher specific gravity sloughed significantly more. Judges frequently indicated that the low specific gravity tubers were "watery" and "metallic" tasting.

Of the tubers of identical specific gravity from fields planted on three dates (Group II), those from the intermediate planting date were rated

TABLE 3.—*Mean scores for various quality characters of boiled potatoes judged in three groups each of which contained three lots differing in (I) specific gravity (II) date of planting, or (III) variety.*

Group:	Variety	Date of Planting	Specific Gravity:	Mean Scores for Indicated Characters[1]					General Desirability[2]
				Color	Slough-ing	Dry-ness	Meali-ness	Flavor	
I	Cobbler	5/17-24	1.090	6.2	4.0	7.8	7.6	8.2	3.6
	Cobbler	5/17-24	1.080	5.4	6.6	5.0	4.8	6.9	2.2
	Cobbler	5/17-24	1.070	5.0	8.4	3.8	3.4	5.8	1.6
			L.S.D., 5 per cent level	n.s	1.1	0.8	1.0	1.0	0.2
			L.S.D., 1 per cent level	—	1.7	1.2	1.5	1.5	0.3
II	Cobbler	5/17-24	1.080	6.4	7.0	5.2	5.0	6.3	2.0
	Cobbler	6/ 4	1.080	7.0	5.3	6.8	7.2	7.4	3.2
	Cobbler	6/27	1.080	4.4	7.8	4.3	4.2	5.6	1.5
			L.S.D., 5 per cent level	0.9	1.1	1.3	1.6	0.9	0.6
			L.S.D., 1 per cent level	1.4	1.6	2.0	2.5	1.3	1.0
III	Cobbler	5/17-24	1.080	6.8	6.8	5.6	4.6	7.6	2.0
	Pontiac	5/17-24	1.080	7.5	7.5	5.2	4.9	7.0	2.2
	Waseca	5/17-24	1.080	5.0	5.1	6.2	6.3	7.1	2.7
			L.S.D., 5 per cent level	0.8	n.s	0.8	1.4	n.s	n.s
			L.S.D., 1 per cent level	1.2	—	1.2	2.0	—	—

[1]Based on score range of 0 to 9. (9=most desirable)
[2]Based on score range of 1 to 4. (4= most desirable)

significantly higher for color, dryness, mealiness, flavor, and general desirability and lower for sloughing than those from the late-planted field. Tubers from the early planting received ratings intermediate to those of the other two plantings. The early and late planted potatoes were often characterized as being "watery" and "metallic" tasting. It is interesting to note that the differences in ratings for the various quality characters between the lots from different plantings were as great as those between lots of different specific gravities.

The differences in ratings for the three lots of different varieties but of identical specific gravity (Group III) were not as great as for the other two groups. Pontiac rated higher in color than Waseca. Waseca rated higher in dryness than Pontiac and higher than both Pontiac and Cobbler for mealiness. Differences in ratings for sloughing, flavor and general desirability were not significant although there was a tendency for Waseca to slough more and to be rated slightly higher in general desirability. The judges frequently considered the Pontiacs to be sweet in flavor, although apparently not objectionably so.

Results of the judgings of two groups of tubers when prepared as mashed potatoes are given in table 4. Cobblers having a specific gravity of 1.090 rated significantly higher in color, dryness, mealiness, flavor, and general desirability than Cobblers of 1.070 specific gravity. Cobblers having a specific gravity of 1.080 were intermediate to the 1.090 and 1.070 tubers in these characters. Although the Cobblers, Pontiacs, and Wasecas of identical specific gravity did not differ in mealiness in this test, the 1.080 Cobblers rated higher in dryness and flavor than Pontiac

TABLE 4.—*Mean scores of various quality characters of mashed potatoes judged in two groups. Group I includes lots differing in specific gravity and variety. Group II includes lots from different dates of planting.*

Group:	Variety	Date of Planting	Specific Gravity:	Mean Scores for Indicated Characters[1]				General Desirability[2]
				Color	Dryness	Mealiness	Flavor	
II	Cobbler	5/17-24	1.070	6.2	4.6	4.4	6.3	1.6
	Cobbler	5/17-24	1.090	8.2	7.5	7.4	8.2	3.4
	Cobbler	5/17-24	1.080	7.6	7.0	6.3	7.4	2.7
	Pontiac	5/17-24	1.080	6.8	5.6	6.0	5.2	2.0
	Waseca	5/17-24	1.080	6.0	5.4	6.0	5.4	1.5
L.S.D., 5 per cent level				1.1	1.4	1.2	1.2	0.8
L.S.D., 1 per cent level				1.5	2.0	1.6	1.7	1.1
I	Cobbler	5/17-24	1.080	8.0	6.4	6.4	7.6	2.7
	Cobbler	6/ 4	1.080	6.8	5.9	5.6	7.8	2.4
	Cobbler	6/27	1.080	6.9	5.2	4.4	6.4	1.7
L.S.D., 5 per cent level				1.0	0.9	1.1	0.8	0.5
L.S.D., 1 per cent level				1.4	1.2	1.6	1.1	0.8

[1]Based on score range of 0 to 9. (9= most desirable)
[2]Based on score range of 1 to 4. (4= most desirable)

and Waseca tubers of the same specific gravity and higher than Wasecas in color and general desirability. The judges frequently indicated that the Pontiacs and Wasecas were sweet tasting while the Cobblers were not.

In contrast to the results obtained with boiled potatoes, tubers from the earliest planting tended to rate slightly higher than those from the second planting when prepared as mashed potatoes although in most instances differences between these two plantings were not significant. However, tubers from both of the earlier plantings were rated better for mashing than those from the late planting, again indicating differences in quality between tubers of identical specific gravity.

Consumer Judging:

Consumer opinions of five lots of potatoes when prepared as boiled, mashed, and baked potatoes are shown in tables 5, 6, and 7, respectively. Data are given in terms of percentages of tests in which the indicated descriptive term for the character was applied to the potatoes under test.

The data for boiled potatoes are given in table 5. Cobblers having a specific gravity of 1.090 were given the highest rating for color, dryness, and mealiness in the greatest number of tests, but, as might be expected, such tubers tended to slough more than those of lower specific gravity. In spite of the tendency for the tubers to slough, Cobblers having a specific gravity of 1.090 were rated highest of the five lots tested for boiling. Surprisingly, the low specific gravity Cobblers (1.070) rated as high

TABLE 5.—*Consumer ratings of boiled potatoes.*

Quality Character Rated:	Choice of Ratings:	Distribution (in per cent) of Consumer Ratings of Potatoes of Indicated Variety and Specific Gravity				
		1.070 Cobbler	1.090 Cobbler	1.080 Cobbler	1.080 Pontiac	1.080 Waseca
Number of Tests Reported		11	9	12	12	11
Color	a. attractive*	45	89	17	25	36
	b. fair**	55	11	66	50	28
	c. unattractive***	0	0	17	25	36
Dryness	a. dry	45	67	42	17	36
	b. slightly moist	45	33	58	75	64
	c. watery or soggy	10	0	0	8	0
Mealiness	a. mealy	55	78	25	0	27
	b. somewhat mealy	35	22	75	67	64
	c. waxy (glossy)	10	0	0	33	39
Sloughing	a. retained normal shape	55	33	42	75	64
	b. broke apart slightly	35	33	50	25	36
	c. broke apart much	10	33	8	0	0
General Desirability	a. excellent	10	45	8	0	18
	b. good	45	33	58	75	36
	c. fair	35	11	17	25	36
	d. poor	10	11	17	0	10

* White
**Slightly yellow or gray
***Yellow or gray

TABLE 6.—*Consumer ratings of mashed potatoes.*

Quality Character Rated:	Choice of Ratings:	Distribution (in per cent) of Consumer Ratings of Potatoes of Indicated Variety and Specific Gravity				
		1.070 Cobbler	1.090 Cobbler	1.080 Cobbler	1.080 Pontiac	1.080 Waseca
Number of Tests Reported		7	5	4	6	4
Color	a. attractive*	43	80	50	23	50
	b. fair**	57	20	25	50	25
	c. unattractive***	0	0	25	17	25
Dryness	a. dry	43	60	75	0	50
	b. slightly moist	57	40	25	83	50
	c. watery or soggy	0	0	0	17	0
Mealiness	a. mealy	57	100	50	0	50
	b. somewhat mealy	29	0	50	83	50
	c. waxy (glossy)	14	0	0	17	0
General Desirability	a. excellent	14	20	50	0	0
	b. good	57	80	25	67	75
	c. fair	19	0	25	33	25
	d. poor	0	0	0	0	0

* White
**Slightly yellow or gray
***Yellow or gray

TABLE 7.—*Consumer ratings of baked potatoes.*

Quality Character Rated:	Choice of Ratings:	Distribution (in per cent) of Consumer Ratings of Potatoes of Indicated Variety and Specific Gravity				
		1.070 Cobbler	1.090 Cobbler	1.080 Cobbler	1.080 Pontiac	1.080 Waseca
Number of Tests Reported		3	8	4	7	5
Color	a. attractive*	0	88	50	29	20
	b. fair**	33	0	50	57	60
	c. unattractive***	67	12	0	14	20
Dryness	a. dry	67	100	75	29	20
	b. slightly moist	33	0	25	59	80
	c. watery or soggy	0	0	0	14	0
Mealiness	a. mealy	33	75	50	0	20
	b. somewhat mealy	0	25	50	100	60
	c. waxy (glossy)	67	0	0	0	20
General Desirability	a. excellent	0	50	25	0	0
	b. good	67	50	75	57	20
	c. fair	0	0	0	29	80
	d. poor	33	0	0	14	0

* White
**Slightly yellow or gray
***Yellow or gray

or higher in color and mealiness than the Cobblers, Pontiacs and Wasecas of intermediate specific gravity (1.080). Of the three variety lots having the same specific gravity (1.080), both Cobbler and Waseca rated higher in mealiness than Pontiac. Despite its low rating from the standpoint of mealiness, the Pontiac variety on the basis of overall desirability was rated as high for boiling as the other lots of the same or lower specific gravity.

The consumer data for mashed potatoes are given in table 6. In the limited number of tests in which the lots were used as mashed potatoes, the ratings were similar to those for boiled potatoes. The high specific gravity potatoes rated highest in color and mealiness. The low specific gravity Cobblers (1.070) rated as high as either the Pontiacs (1.080) or Wasecas (1.080) for these characters. Of the three lots of the same specific gravity, Cobbler and Waseca rated higher than Pontiac in dryness and mealiness. Cobblers tended to be rated higher as mashed potatoes than either Pontiacs or Wasecas of the same specific gravity. As might be expected, since sloughing does not reduce their value for mashing, the high specific gravity potatoes rated highest of the five lots tested.

The consumer data on baked potatoes are given in table 7. From the limited data obtained, it is apparent that the consumers preferred the high specific gravity potatoes for baking. However, that specific gravity is not the only factor which influenced consumer preference is indicated by the fact that of the three lots of identical specific gravity, consumers considered the Cobbler somewhat better for baking than either the Pontiac or Waseca.

Discussion

In view of the fact that specific gravity grading has been suggested as a means of providing consumers with potatoes having predetermined cooking qualities, the degree to which specific gravity gives an estimate of the cooking quality of potatoes is an important question.

The data presented in this paper indicate that the specific gravity of potato tubers may provide a poor estimate of their cooking quality. It is quite apparent that within potatoes of a given variety harvested from a given field those tubers high in specific gravity will have a greater degree of mealiness, will tend to be dryer, will slough more, and may even produce a cooked product of more desirable color than low specific gravity tubers from the same crop. However, as these data show, tubers of two varieties even though they have the same specific gravity may be quite different in these components of quality. Likewise, tubers of one variety having the same specific gravity but produced under different environmental conditions may be quite different in cooking quality as indicated by the differences between tubers from different dates of planting in this study. Thus, one lot of tubers having a specific gravity of 1.090, for example, may conceivably be quite different in cooking quality from other tubers of specific gravity 1.090 grown in the same general producing area even though both lots are of the same variety. To determine which of the two lots is the better for any particular cooking method would still require cooking tests.

Although it is apparent that specific gravity grading of potatoes is

not a satisfactory method for estimating cooking quality, it does have one desirable feature. Such grading would provide consumers with potatoes of more uniform cooking quality by reducing the variability in specific gravities normally present in a potato crop.

Summary

1. Tests were conducted to obtain the relative cooking qualities of (a) tubers of one variety graded into three specific gravity classes, (b) tubers of one variety but from three plantings graded into one specific gravity class, and (c) tubers of three varieties graded into one specific gravity class.

2. Limited consumer cooking tests were conducted with tubers from groups (a) and (c) above.

3. Within Irish Cobbler potatoes from a planting made on May 17, tubers having specific gravity of 1.090 were rated higher for most quality characters than tubers having specific gravities of 1.080 or 1.070 when prepared as boiled or as mashed potatoes.

4. Within Irish Cobbler potatoes having a specific gravity of 1.080, tubers from a crop planted on June 4 were rated higher for most quality characters than those from May 17 or June 27 plantings when prepared as boiled potatoes. When prepared as mashed potatoes, tubers from the two early plantings were rated higher in cooking quality than those from the late planting.

5. Within potatoes having specific gravity of 1.080 from plantings made May 17-24, tubers of Waseca rated higher in dryness than those of Pontiac and higher in mealiness than both Pontiac and Cobbler when prepared as boiled potatoes. When prepared as mashed potatoes the three varieties did not differ in mealiness, but Cobblers rated higher in dryness and flavor than Pontiac and Waseca.

6. In limited consumer tests, Irish Cobbler tubers having a specific gravity of 1.090 were preferred for boiling, mashing, and baking over Cobblers, Wasecas, and Pontiacs of lower specific gravity. Of the three variety lots having the same specific gravity, Cobbler and Waseca rated higher in mealiness than Pontiac when prepared as baked or mashed potatoes. For baking, consumers preferred Cobblers to either Pontiacs or Wasecas of the same specific gravity.

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A RAPID TEST FOR THE PREDICTION OF COLOR IN THE COOKED POTATO*

N. R. THOMPSON[1] AND E. J. WHEELER[2]

A considerable amount of work has been done on the development of gray discolorations in cooked potato tubers. The most important of these discolorations tends to be localized at the stem end of the tuber and is often referred to as stem-end blackening. Few workers have attempted to investigate a means of predicting this color of the cooked product.

The authors, faced with the problem of selecting large numbers of seedlings each year, required a rapid test for color of the cooked potato. Wheeler (1939) proposed that the color of a core sample from the stem end of the tuber immersed in 95 per cent ethyl alcohol for one hour would indicate the color of the cooked potato. To make a further study of this method of predicting color, 324 samples of potatoes obtained from a survey in the Province of Ontario, and 73 seedling lines were scored for color by the rapid method and by cooking.

EXPERIMENTAL METHODS

Five tubers were selected at random from each sample. The potatoes were washed and numbered. A core sample was removed from the region of the stem end with a cork borer, ⅜ of an inch in diameter. The core was placed in a vial containing sufficient 95 per cent ethyl alcohol for complete immersion. Each core was rated according to the discoloration which had developed at the end of two hours. The color variations corresponding to the numerical values used for rating the core samples were established by Wheeler (1939) and are shown in figures 1 and 2. The scale for the numerical evaluation of the discoloration of the core samples is given on the next page.

The tubers were then peeled and boiled for 20 to 30 minutes in stainless steel saucepans. They were considered cooked when they offered little resistance to penetration with the tines of a fork. The potatoes were drained and placed over the heat, for approximately one minute, to dry.

Each tuber was placed on a white china plate for scoring by two judges, each judge working independently. The tuber was mashed with a fork and color was rated zero to four with subdivisions at intervals of .25. The highest value, four, represented the whitest potatoes. The scores for color were obtained by averaging the values assigned by the two judges.

Analysis of variance and co-variance were applied to the data. Coefficients of correlation between the color of the raw core in alcohol and the color of the cooked potato were determined.

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Color of Core in Alcohol	Rating
Cortex black or dark gray, pith black or brown	1
Cortex black or dark gray, pith containing dark areas	2
Cortex black or dark gray, pith white, or light gray, with a few dark areas	3
Cortex black or dark gray, pith light gray or white	4
Cortex dark gray, pith white	5
Cortex light gray, pith white	6
Cortex white to very light gray, pith white	7
Cortex white, pith white	8

Discussion and Conclusions

The mean values of the raw cores of each variety in alcohol and of the score of the cooked potatoes showed highly significant differences between means, indicating that variety influenced color. Environment, such as location and agronomic practices, also has an effect on color, since the differences between sample means were significant.

The association between the two methods of evaluating the color of a cooked potato, immersion of core sample in 95 per cent ethyl alcohol and cooking and judging the cooked potato, was strong. This is shown in table 1 by the coefficient of correlation, r—0.623, for all tubers tested. A pictorial comparison of cores in alcohol and cores of cooked potatoes, one for each class rating, is shown in figure 3.

The close association was true for all varieties except Green Mountain. Here the relationship of the two tests was not significant for the ten tubers tested. This variety was prone to discolor in any part of the tuber so that one core did not adequately represent that tuber.

Coefficients of correlation between samples and within samples of the four varieties containing the largest number of tubers were highly significant. Therefore, five tubers were sufficient to show the relationship. The coefficient of correlation between samples of the Ontario variety was not significant, probably because of the fewness of samples. Within the samples of this variety the relationship between the two methods of scoring was highly significant.

Although the core samples of raw potatoes remained in alcohol for two hours, a large bank of vials permitted continuous operation. Therefore much less time was required to determine the color by the alcohol immersion method than by cooking and conventionally scoring the potatoes.

The rapid, simple test for the color of a core from the stem end of the tuber may be used to predict the color of the potato when cooked. In addition to the time and labor saved, the tuber is not destroyed. This fact makes the test invaluable in a potato breeding program. The color of a potato seedling may be predicted in the early stages of development, when all tubers of the seedling must be saved for propagation.

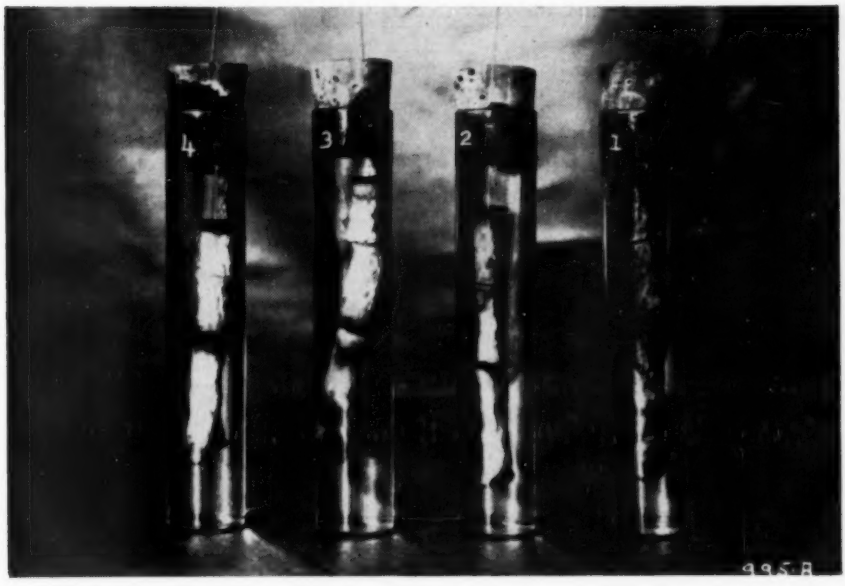

FIGURE 1.—Color and rating of potato cores in alcohol.

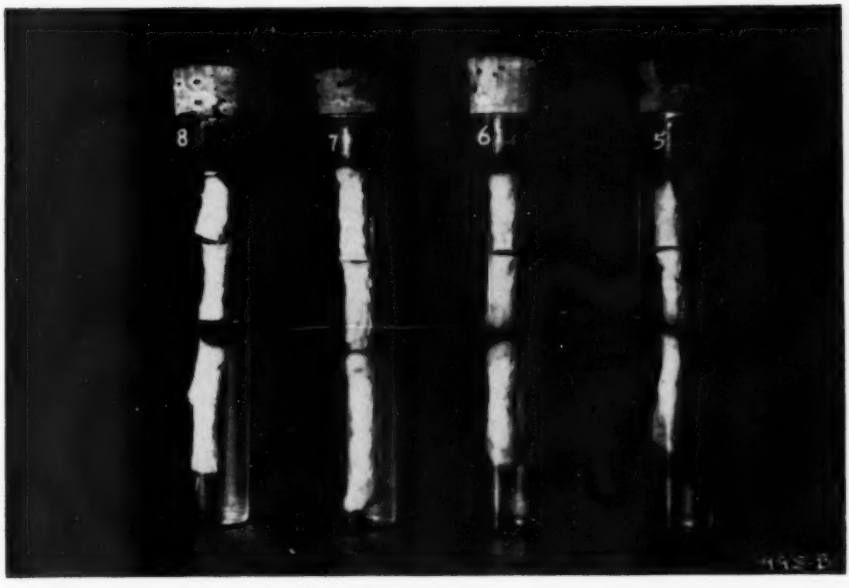

FIGURE 2.—Color and rating of potato cores in alcohol.

TABLE 1.—*Coefficients of correlation between alcohol color ratings of raw tubers and the color scores of cooked potatoes*

Variety	No. of Tubers	Total for Variety	No. of Samples	Between Samples	Within Samples
Part A[1]					
Katahdin	975	.792**	195	.847**	.768**
Sebago	240	.915**	48	.825**	.999**
Chippewa	205	.564**	41	.693**	.443**
Irish Cobbler	135	.656**	27	.903**	.551**
Ontario	25	.961**	5	.813	.975**
Warba	10	.945**	2	—	.935**
Teton	10	.724**	2	—	.724**
Green Mountain	10	.017	2	—	.505
Netted Gem	5	.987**	1	—	.987**
Local	5	.907**	1	—	.907**
For all tubers	1620	.623**	324	.861**	.465**
Part B[2]					
Seedlings	73	.646**			

**Exceeds the 1 per cent level of significance.
[1]Samples obtained in a survey in the Province of Ontario—1950.
[2]Seedlings grown on the Ontario Agricultural College Potato Farm—1950.

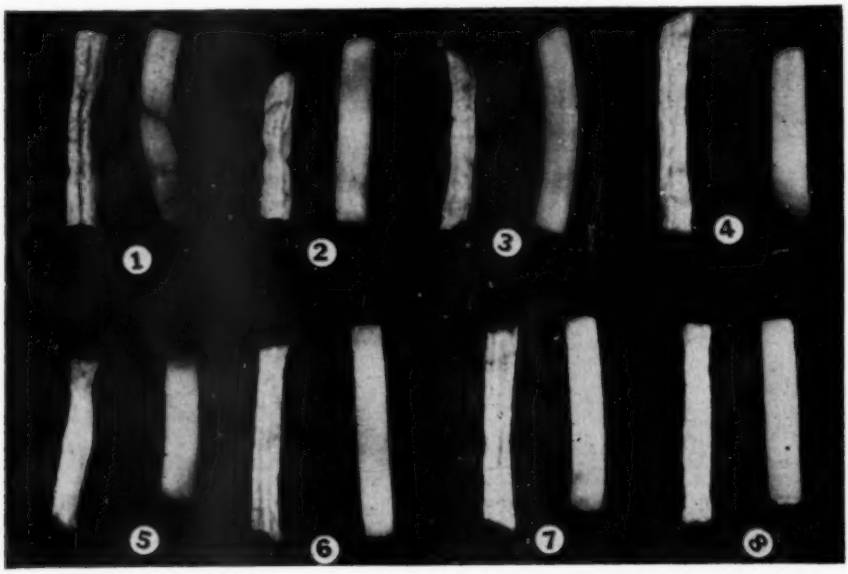

FIGURE 3.—Alcohol color ratings, 1 to 8 of eight potato tubers. The paired cores are from the same tuber — raw core in alcohol, left; core from cooked potato, right.

Summary

1. The color of a core of a raw tuber immersed in 95 per cent ethyl alcohol was used as a rapid test to indicate the color of that particular potato when cooked.
2. A total of 1,693 tubers, comprising 10 varieties and 73 seedlings, was tested.
3. At the end of two hours the cores were scored for discoloration. The potatoes used to provide the raw cores were also cooked and scored for color. A core remaining white in alcohol indicated that the potato would cook white.
4. Between the color of the core in alcohol and the color of the cooked potato coefficients of correlation $r=0.623$ for the 1,620 tubers of the named varieties and $r=0.646$ for the 73 seedling tubers showed a close relationship . Therefore, the rapid method of determining color by cores in alcohol was indicative of the color of the potato when cooked.
5. The rapid method did not destroy the tuber.

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POTATO NEWS AND REVIEWS

POTATO GROWING IN BRAZIL[1]

FLORIANO F. GUIMARAES[2]

Brazil is the largest country in South America and one of the largest countries of the world. Its area reaches over three million square miles and only Siberia and Canada surpass Brazil in continuous land space. Brazil is located mostly in the Southern hemisphere from about 5° north latitude to approximately 34° south latitude, hence having a range from tropical to temperate climate. It has a population of 50,000,000 inhabitants. The national language is Portuguese since Brazil belonged to Portugal until 1822 when its independence was proclaimed. Its form of government is a republic like the United States.

The most important crops that are grown in Brazil in order of economic value are: coffee, corn, rice, cotton, dry beans, sugar-cane, manioc, wheat, irish-potatoes, bananas, cacao, tobacco, oranges, sweet-potatoes, castor-oil and peanuts. Despite its steady industrial development Brazil is essentially an agricultural country. Nevertheless only about 5 per cent of its area is actually under cultivation. 375,000 acres are devoted to potatoes with an estimated production of 30,000,000 bushels. Many factors contribute to the low average yield of 80 bushels per acre.

The *per capita* consumption of potatoes is low and doesn't exceed 30 pounds, although the whole crop is used as human food. Beef, dry beans, rice, wheat, corn, manioc and even sweet-potatoes comprise a more important share in the Brazilian diet than does the irish-potato.

Brazil produces sufficient potatoes for its own table stock use. None is exported. Occasionally some potatoes are imported for seed purposes. Holland is by far the leading source of seed potatoes and before World War II Germany also held a prominent place among the countries that shipped seed to Brazil.

Potatoes are produced in each of the 48 states of the United States whereas in Brazil they are successfully grown in only seven of its twenty states which are located in the central and southern part of the country. These states are Minas Gerais, Espirito Santo, Rio, Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul. The climatic conditions in the remainder of the states are not favorable for potato growing and its culture is rare or completely absent.

Ninety per cent of the potatoes of Brazil are produced in Sao Paulo, Parana and Rio Grande do Sul. These states are situated above 20° south latitude. The potato is sown and harvested in almost every month of the year in the state of Sao Paulo. In the other two southern states the potato as a rule is grown twice a year, one crop being sown in the latest part of summer or in the very early autumn (February-March)

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and the other one is sown at the end of the winter or the first days of spring (August-September). It is not practical for farmers to avoid one planting period per year because of excessive sprouting of the seed potatoes in storage.

One of the states that possesses the most suitable climate for potato growing is the southernmost one, Rio Grande do Sul, which has an area of 109,200 square miles and a population of 4,000,000 inhabitants. Its size is about the same as Colorado and its climate is classified as temperate but even so we can not consider it an ideal climate for potato growing. The inconsistent temperatures and rainfalls are the main handicaps that make potato culture at times a very hazardous enterprise. During its hottest months (January and February) the average normal temperatures range between 67° and 81° and those of the coldest months (July, August and beginning of September) range between 48° and 59°. Snow occurs very rarely, but heavy frosts are frequent during the winter months (July, August and September).

The normal annual rainfall varies from 43 inches to 98 inches and the normal annual relative humidity ranges from 75 to 87 per cent. The rainy season in Rio Grande do Sul and the other southern states occurs in winter and in the beginning of spring, but in the state of Sao Paulo and in the central states the rainy season is summer.

The state of Rio Grande do Sul grows approximately 100,000 acres of potatoes and contributes more than 9,000,000 bushels to the national production. The average yield is about as low as the national one but in the best soils yields of 750 to 800 bushels have been recorded by the writer.

The potato is grown in practically every county of the state from a few feet above sea level up to 3600 feet, but the bulk of its culture is concentrated in four well-defined regions called the plateau, the northeastern sierra, the central depression and the southeastern sierra which includes the Atlantic Ocean coastal section. The soils of these regions are suitable for potato growing as far as texture is concerned but in general they are, as almost all Brazilian soils, somewhat low in phosphorus content.

The climate is not ideal for successful potato growing. The potato crop often suffers from extreme fluctuations in temperature and from prolonged periods of drought or excessive rainfall.

The latter part of the winter is characterized by heavy rainfalls. The beginning of the spring in the southern part of Brazil is characterized by the occurrence of low temperatures and sometimes of late frosts.

The above-mentioned unfavorable circumstances are responsible for the fact that the potato has to grow within relatively short vegetative cycles, and the use of early varieties with a short rest period is a *sine qua non* condition. Ordinarily these early varieties are not as good yielders as the medium-late or the late ones. The latter must be specially treated to induce sprouting before planting. Therefore, varieties that do not possess a rapid type of sprouting cannot compete successfully with the weeds that always appear simultaneously or even before the emergence of the small potato plants, making difficult and sometimes entirely impossible good cultivation procedures.

The average size of the farms in the potato growing areas is about 80

acres whereas for the mixed type of farms and for general livestock farms it is approximately 100 and 1800 acres respectively. Potatoes are not grown on these farms or, if so, in very small acreages.

The farmers engaged in potato growing are natives of Brazil and immigrants from Portugal, Spain, Italy and Germany. Polish and Russian settlers take a large part in the culture of the potato in the state of Parana whereas the Japanese and Italian immigrants together with the natives are the principal potato farmers in the state of Sao Paulo.

The potato is rotated with crops such as corn, dry beans, and wheat and sometimes, cowpeas and onions. The crop is almost entirely handled manually. In the small areas the seed tubers are planted with the use of hoes and in large areas with the help of plows. There is a tendency among farmers to use very small tubers for seed purposes despite the recommendations of the government agencies against such practices. Seed tubers are not cut but used whole. They are planted 8 inches apart in the row and a distance of 24 inches is maintained between the rows. The use of commercial fertilizers is a common practice. These are applied in the furrow at planting time or more commonly are scattered by hand over the field and disked in before that time.

Hand cultivation with hoes is the most common practice but some farmers use cultivators of the Planet Junior type pulled by horses or pushed by man power. Specially devised types of hilling equipment are also used. Very seldom is cultivation done by more advanced types of machinery.

Harvesting operations are also carried on by hand using hoes and even plows. The potatoes are not washed and it is a common practice to deliver them to the market in 133 pound burlap bags almost immediately after harvesting. The dealers and shippers do not have specialized types of potato warehouses but store the potatoes in a general type of storage building.

The potato tubers are shipped to the central and northern states by sea in vessels that lack any kind of refrigerating systems, and it is not uncommon that shipments arrive at their destination in poor condition. Practically no improvements have been made to avoid these troubles. No efforts have been put forth to encourage a larger growing of the potato and to provide a large increase in the amount of such an important food in the national diet. The potatoes are graded according to federal regulations for shipping and even for selling at the local markets.

In the central states there is a decided preference for yellow-fleshed tubers but in the southern states people do not care about the color of the potato flesh. Red-skinned potatoes and very large tubers, however, are not popular among the consumers.

The prices of the product vary according to the seasonal influences upon the crop but in general the market for potatoes is favorable.

The most important diseases that attack the potato are the viruses, early and late blight, and brown-rot or southern bacterial wilt. Late blight and the virus disease leaf-roll are the most troublesome diseases. Scab is not a very common disease; ring-rot, *Fusarium* and *Verticillium* wilt are practically unknown in Brazil.

The most common insect enemies of the potato are the aphids and other vectors of the virus diseases, the tuber moths, flea beetles, and gray

blister beetles. The nematodes or rootworms sometimes bother the potato tubers, principally on sandy soils and during dry seasons.

Spraying and dusting to control diseases and insects are not common practices. The farmers are not willing to carry on control practices even though the government agents supply the necessary technical information as well as materials and equipment under well organized extension programs. In the state of Sao Paulo the Japanese farmers are doing a very good job so far as spraying and dusting are concerned. We believe that with the relatively recent development of the new insecticides and fungicides which are more easy to handle than the old ones, the control of insects and diseases can be more effectively accomplished by the potato farmers. The spraying and dusting equipment is made in Brazil or imported from the United States and Germany, and almost all of them are manually operated.

The southern Brazilian farmers use their home grown seed or import seed from foreign countries. The main foreign source of seed is Holland. Before World War II, Germany provided large amounts of seed tubers, and Poland, Canada, the United States and Argentine sometimes supplied very small amounts of seed potatoes to Brazil.

The most common Dutch varieties imported for seed are Bintje and Eigenheimer whereas Konsuragis is the most popular of the German varieties. These and approximately 400 additional varieties that have been tried are not well adapted to the growing conditions in southern Brazil.

Three other varieties of unknown origin, namely Parana Ouro, Rosa and Rama Verde are also extensively grown but do not yield any better than the formerly mentioned ones.

Potato Research and Improvement in Brazil

Potato research activities are being conducted in the states of Sao Paulo and Rio Grande do Sul where studies dealing chiefly with the physiology of the plant, transmission of the principal diseases, and also with insects and their control, are being conducted. Other projects such as cultural methods, weed eradication, sprouting prevention and breaking the rest period of the potato tubers are maintained.

The laboratories engaged in research work are the Instituto Agronomico, Campinas, and the Instituto Biologico, city of Sao Paulo, in the state of Sao Paulo and the Secretaria da Agricultura, city of Porto Alegre, and the Instituto Agronomico do Sul, city of Pelotas, in the state of Rio Grande do Sul. Some private firms conduct a limited amount of research work dealing with the application of fungicides and insecticides.

Potato breeding work is being conducted only in the two abovementioned states, in Sao Paulo at the Instituto Agronomico, Campinas, and in Rio Grande do Sul at the Instituto Agronomico do Sul, Pelotas, and at the Estacao Experimental de Horticultura, Rio Grande. In the Estacao Experimental de Horticultura, which is a state institution, the objectives of its breeding program are to develop varieties:

(1) adapted to two annual growing periods; (2) possessing rapid and uniform sprouting ability; (3) possessing high yielding ability with smooth tuber shape, few and shallow eyes, good flavor and market

acceptability; (4) possessing resistance to virus, fungal and bacterial diseases and (5) possessing resistance to insects and worms.

The breeding program at the experimental station, which is one of the largest and continuous in South America, was initiated ten years ago and has been conducted entirely under field conditions. During the second part of 1952 a set of cold frames and a small greenhouse were built to remove the former handicaps that have hampered the development of the breeding program.

As an example of the difficulties encountered to execute such a breeding project under field conditions we should register that, on the average 60 per cent of the seedlings were lost in the past from the transplanting until the harvesting period, and that all the seedlings from crossed and selfed seed of the year 1949 were destroyed soon after germination on account of uncontrollable adverse weather conditions.

The prevailing climatic conditions during the month of November (spring) in the region where the Estacao Experimental de Horticultura is located are very favorable for flowering and for fruit-setting. The commercial varieties of potato, which belong to the species *Solanum tuberosum*, bloom freely as well as all the other species of the genus *Solanum* so far introduced.

The principal difficulty in that region is the wind that blows strongly and constantly during the spring season. Various types of windbreaks are used to protect the plants in the field.

The source of the breeding material has been European, North American and South American countries. There are no native wild types of potatoes in Brazil and most of the foreign material shows poor adaptability and sometimes it is very hard to maintain it in the collections. Some of them, however, have been very useful for the breeding work and one American representative, 96-56, a selection from the cross 3895-13 (W German race) X Earlaine contributed greatly to the good results already achieved in the field of late blight resistance. Most of the resistant seedlings have 96-56 as one of their ancestors, but many other American and German stocks have supplied sources of resistance to blight to the station breeding program.

Besides late-blight resistance less consistent achievements have been reached in breeding for resistance to virus diseases and to early-blight, and no breeding work has been done so far on brown-rot and insect and worm resistance.

We agree that the solution of the potato problem in Brazil is not an easy task, but we consider that we have already a good and sound basis connected with the work that has been conducted in Sao Paulo and chiefly Rio Grande do Sul to build up at least a regional breeding program and carry it on successfully if sufficient support can be provided by the government. Of course there are many things still to be accomplished by a well organized extension service, but the real solution of the problem remains in the creation of types well adapted to the Brazilian environmental conditions and resistant to the prevalent diseases and pests.

A good beginning has been made at the Estacao Experimental de Horticultura in the state of Rio Grande do Sul.

The principal breeding work is being conducted toward obtaining varieties resistant to late-blight. More than 300 seedling varieties that are

resistant to the common races of late blight *Phytophthora infestans* have already been secured and are being submitted to various trials. One of these seedling varieties, a product of a cross between the German variety Cuculus and the American seedling variety 96-56 is going to be released to all growers in the near future.

Another seedling variety, a self from the German variety Starcheragis, that shows a high degree of tolerance to late blight aside from other good qualities, has already been named Gaucha and delivered to the public. Still another seedling variety that traces back to a cross between the German variety Lichtblick and Earlaine is also going to be named and released this year. It is a very good yielder. Although it is late blight susceptible, it escapes the disease because of its earliness.

CALL FOR TITLES OF PAPERS

The Annual Meeting of the Potato Association of America will be held September 6-9 at Madison, Wisconsin. This annual meeting will be held under the auspices of the American Institute of Biological Sciences (AIBS) along with 18 other biological societies.

Complete programs of *all* societies will be printed in the AIBS Bulletin. In order to do this, titles of papers to be presented must be in the hands of the secretary by **June 2.**

DEADLINE FOR PAPERS

Please send titles of papers you plan to present at the annual meeting, *prior* to **June 2.** Titles received after this date will not be listed in the program printed in the AIBS Bulletin. This may seem early but please send in a title if you possibly can.

A sample form for submitting titles, authors and institutional affiliations follows:

ALDRICH, FREDERICK A., Department of Zoology,
Rutgers University, New Brunswick, N. J.
A Symbiotic Relationship Involving *Molgula manhattensis* (DeKay) and *Mya arenaria* L.
(Illustrated, 3¼ x 4). 15 mins.

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